CHAPTER IV - SUMMARY OF FORECAST VERIFICATION

1. ANNUAL FORECAST VERIFICATION

a. Western North Pacific Area

Forecast positions at warning times and 24-, 48-, and 72-hour valid times were verified against corresponding best tracks. Vector errors and right angle errors for individual tropical cyclones were calculated and are displayed in Table 4-1. Annual mean errors for all tropical cyclones are listed in Table 4-2 for comparison. Frequency distributions of the vector errors for 24-, 48-, and 72-hour forecasts on all 1980 tropical cyclones are shown in Figure 4-1. Annual mean vector errors are graphed in Figure 4-2.

TABLE 4-1. FORECAST ERROR SUMMARY FOR THE 1980 WESTERN NORTH PACIFIC SIGNIFICANT TROPICAL CYCLONES (ERRORS IN NAUTICAL MILES)

		WARNING			24 HOUR			48 HOUR			72 HOUR		
		POSIT ERROR	RT ANGLE ERROR	# WRNGS	POSIT ERROR	RT ANGLE ERROR	# WRNGS	POSIT ERROR	RT ANGLE ERROR	# WRNGS	POSIT ERROR	RT ANGLE ERROR	# WRNGS
1.	TD-01	26	12	17	102	20	14	94	53	11	157	65	7
2.	TS CARMEN	32	19	9	154	90	9	266	179	7	250	218	5
3.	TY DOM	29	15	42	137	106	39	191	133	27	324	237	23
4.	TY ELLEN	14	10	34	130	76	31	300	201	27	484	414	23
5.	TS FORREST	37	17	26	106	56	22	227	123	18	388	227	14
6.	TS GEORGIA	44	29	12	112	52	10	199	140	6	299	293	2
7.	TS HERBERT	29	19	15	78	39	11	130	102	7	64	53	2
8.	TS IDA	21	11	23	98	37	19	182	73	14	253	126	7
9.	TY JOE	18	13	25	99	61	20	197	98	17	301	184	13
10.	TD-10	42	33	7	115	92	2						
11.	ST KIM	23	16	29	95	63	25	159	109	22	211	123	18
12.	TY LEX	18	11	36	137	97	32	314	251	24	499	421	20
13.	TY MARGE	20	11	31	114	58	26	276	180	20	506	371	12
14.	TD-14	126	67	2									
15.	TY NORRIS	26	19	20	103	78	17	183	134	13	212	144	9
16.	TD-16	70	20	5	241	28	1						
17.	TY ORCHID	36	22	19	95	62	16	175	98	12	284	179	8
18.	TY RUTH	20	11	13	113	60	9	241	130	5	314	131	1
19.	TY PERCY	26	18	20	164	113	17	245	172	14	309	291	9
20.	TY SPERRY	23	17	22	176	133	19	324	236	10	571	413	8
21.	TS THELMA	81	43	16	145	83	11	358	218	7	978	577	4
22.	TY VERNON	30	18	25	145	77	21	216	185	17	248	203	13
23.	ST WYNNE	18	12	44	119	66	41	248	137	36	370	273	30
24.	TS ALEX	28	17	8	118	46	4						
25.	TY BETTY	23	14	39	131	81	36	306	215	29	524	405	28
26.	TS CARY	38	27	14	180	158	11	421	358	7	630	540	3
27.	TY DINAH	25	14	17	145	93	13	304	175	9	673	336	5
28.	TS ED	40	21	20	146	120	16	292	262	11	402	378	4
ALL FORECASTS		28	16	590	126	79	492	243	164	370	389	287	268

TABLE 4-2. ANNUAL MEAN FORECAST ERRORS (NM) FOR THE WESTERN NORTH PACIFIC

	24-HR		48-HR		72-HR	
YEAR	VECTOR	RIGHT ANGLE	VECTOR	RIGHT ANGLE	VECTOR	RIGHT ANGLE
1971	111	64	212	118	317	177
1972	117	72	245	146	381	210
1973	108	74	197	134	253	162
1974	120	78	226	157	348	245
1975	138	84	288	181	450	290
1976	117	71	230	132	338	202
1977	148	83	283	157	407	228
1978	127	75	271	179	410	297
1979	124	77	226	151	316	223
1980	126	79	243	164	389	287

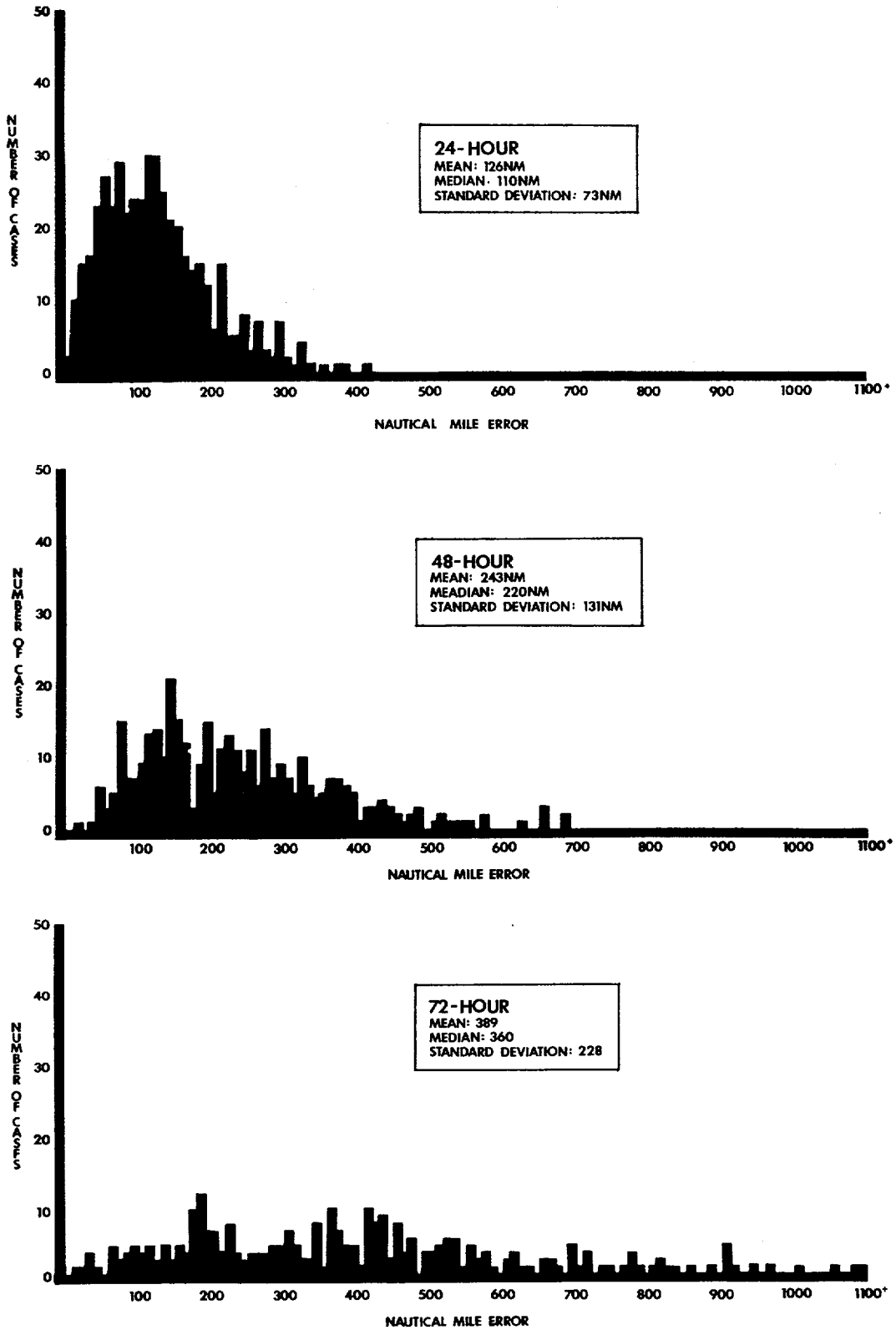


FIGURE 4-1. *Frequency distribution of 1979 24-, 48-, and 72-hour forecast vector errors for all significant tropical cyclones in the western North Pacific.*

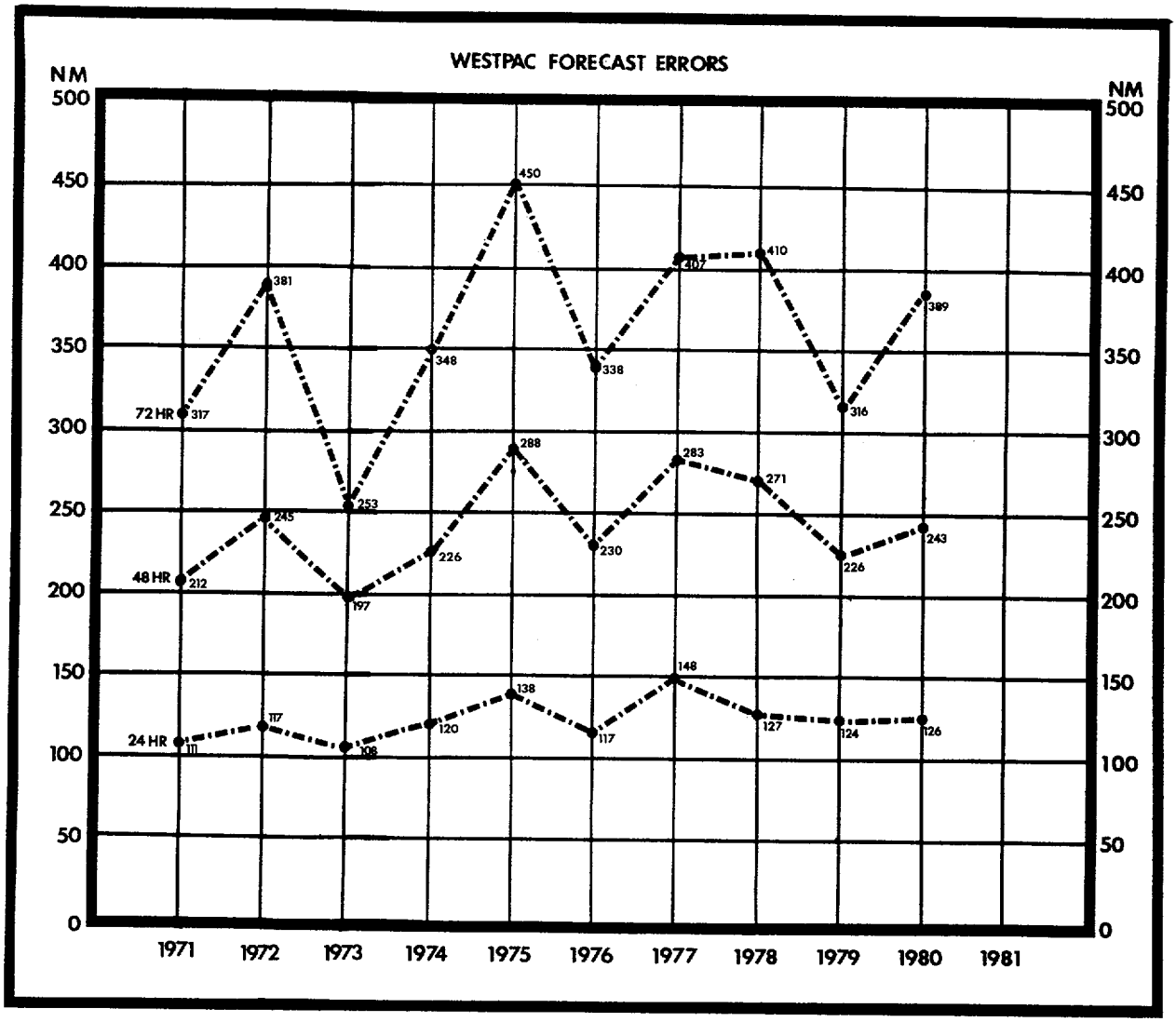


FIGURE 4-2. Annual vector errors (nm) for all cyclones in the western North Pacific.

Intensity verification statistics for all significant tropical cyclones in the western North Pacific area are depicted in Figures 4-3 and 4-4. The average absolute magnitude of the intensity error as well as the intensity bias (algebraic average) are graphically depicted. This year's data show that the absolute magnitude of JTWC's forecast intensity errors (Fig. 4-3) has not changed significantly from 1979 throughout 72 hours. The mean algebraic errors (Fig. 4-4), however, show that JTWC had a definite negative bias through 72 hours. This negative bias means that JTWC consistently under forecast tropical cyclone intensity during 1980. Verification of intensity forecasts by objective aids is also depicted in Figures 4-3 and 4-4. (An explanation of the objective forecasting aids is found in this chapter, Section 2-Comparison of Objective Techniques.)

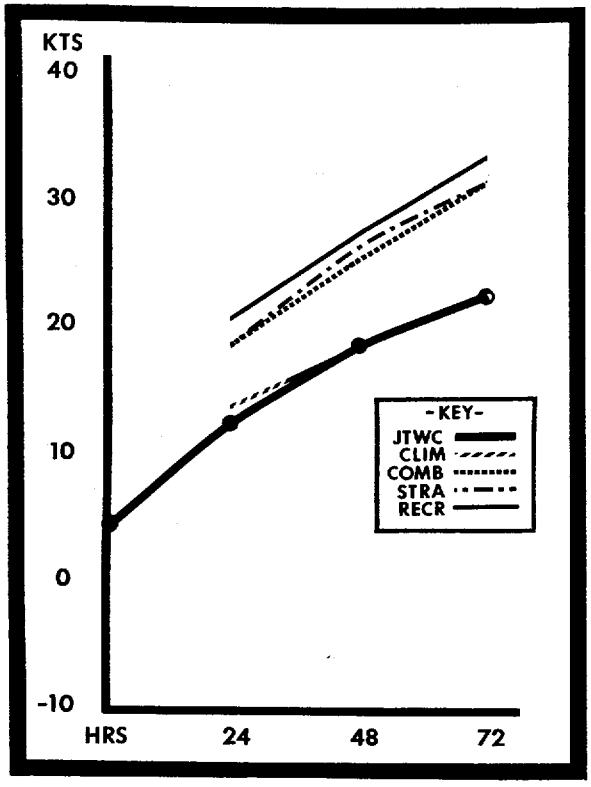


FIGURE 4-3. *Comparison of average intensity errors (magnitude) for all cyclones in the western North Pacific.*

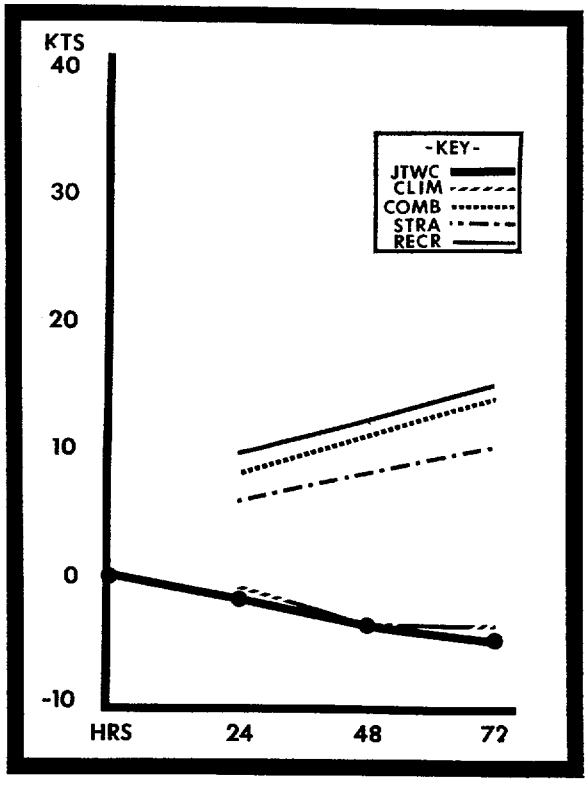


FIGURE 4-4. *Comparison of average intensity errors (biases) for all cyclones in the western North Pacific.*

b. North Indian Ocean Area

Forecast positions at warning, 24-, 48-, and 72-hour valid times were verified for TC 23-80 and TC 27-80 by the same methods used for the western North Pacific. It should be noted that, due to the abnormally low number of Indian Ocean tropical cyclones, the forecast error statistics are not considered to be representative of a significant improvement in forecasting for that region. Table 4-3 is the forecast error summary for TC 23-80 and TC 27-80. Table 4-4 contains the annual average of forecast errors back through 1971. Vector errors are plotted in Figure 4-5. Seventy-two-hour forecast errors were evaluated for the first time in 1979.

Forecast intensities are not verified for North Indian Ocean tropical cyclones.

TABLE 4-3. FORECAST ERROR SUMMARY FOR THE 1980 NORTH INDIAN OCEAN SIGNIFICANT TROPICAL CYCLONES.

	WARNING			24 HOUR			48 HOUR			72 HOUR		
CYCLONE	POSIT ERROR	RT ANGLE ERROR	# WRNGS	POSIT ERROR	RT ANGLE ERROR	# WRNGS	POSIT ERROR	RT ANGLE ERROR	# WRNGS	POSIT ERROR	RT ANGLE ERROR	# WRNGS
TC 23-80	24	16	8	120	66	4	-	-	-	-	-	-
TC 27-80	65	55	6	109	81	3	93	87	2	167	126	1
*ALL FORECASTS	41	33	14	115	73	7	93	87	2	167	126	1

*NOTE: 1980's error statistics are not considered to be representative of forecast accuracy trends due to the small number of JTWC forecasts which were verified.

TABLE 4-4 ANNUAL MEAN FORECAST ERRORS FOR THE NORTH INDIAN OCEAN (the Arabian Sea was not included prior to 1975).

	24-HR		48-HR		72-HR	
YEAR	VECTOR	RIGHT ANGLE	VECTOR	RIGHT ANGLE	VECTOR	RIGHT ANGLE
1971	232	-	410	-	-	-
1972	224	101	292	112	-	-
1973	182	99	299	160	-	-
1974	137	81	238	146	-	-
1975	145	99	228	144	-	-
1976	138	108	204	159	-	-
1977	122	94	292	214	-	-
1978	133	86	202	128	-	-
1979	151	99	270	202	437	371
1980	115	73	93	87	167	126

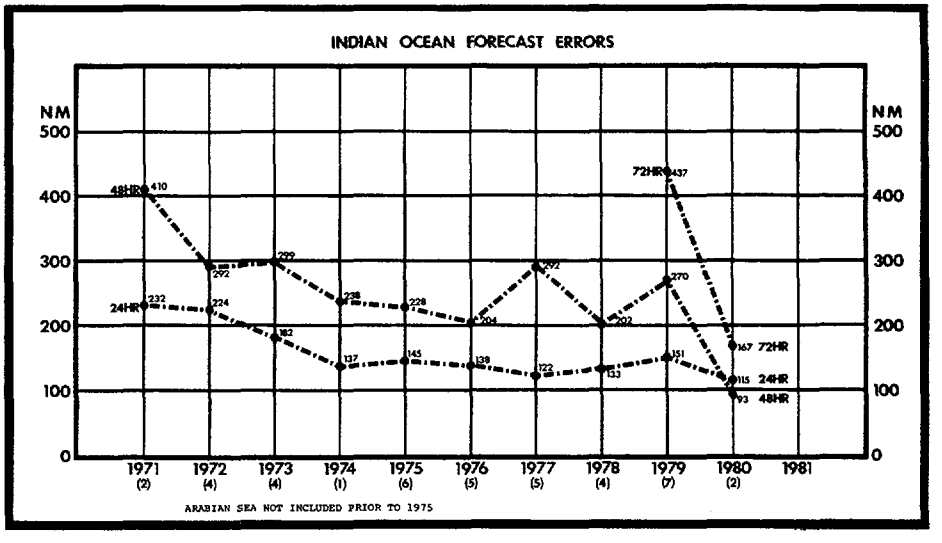


FIGURE 4-5. Annual mean vector errors (nm) for all cyclones in the north Indian Ocean.

2. COMPARISON OF OBJECTIVE TECHNIQUES

a. General

Objective techniques used by JTWC are divided into four main categories: (1) climatological and analog techniques; (2) extrapolation; (3) steering techniques; and (4) a dynamic model. The analog technique provides three movement forecasts: one for straight moving cyclones, one for recurving cyclones, and one which combines the tracks of straight, recurving, and all other cyclones that do not meet the criteria of straight or recurving analogs. All objective techniques, except the Tropical Cyclone Model (TCM), were executed using operational data available at warning time. The TCM used analysis fields for initialization that were not available at warning time. The TCM forecasts were received at JTWC 9 to 12 hours after warning time.

b. Description of Objective Techniques

(1) EXTRAPOLATION -- A track from the 12-hour old preliminary best track position through the current warning position which is linearly extrapolated to 24 and 48 hours.

(2) CLIM -- A climatological aid which provides 24-, 48-, and 72-hour tropical cyclone forecast positions and intensity changes for initial latitude/longitude positions. The data are arranged by months and are based on historical data from 1945 to 1973.

(3) HPAC -- The 24- and 48-hour forecast positions are derived from the midpoints of straight lines connecting the 24 - and 48-hour positions on the EXTRAPOLATION track at the CLIM track.

(4) TCM -- The dynamic Tropical Cyclone Model (TCM) is a coarse mesh (220 km) primitive equation model. The digitized tropical cyclone warning position is bogused in the 850 mb wind and temperature fields of the FLENUMOCEANCEN Global Band Analysis. Hemispheric forecast data are used on the boundaries.

(5) CYCLOPS -- An updated version of the HATTRACK/MOHATT steering program which can provide steering forecasts at the 1000, 850, 700, 500, 400, 300, and 200 mb levels. The program can be run in the unmodified or modified version with analysis or prognostic fields. The program advects a point vortex on a preselected analysis and/or smoothed prognostic field at designated levels in 6-hour time steps through 72 hours. In the modified version, the program uses the previous 12-hour history position to compute the 12-hour forecast error and applies a bias correction to the forecast positions. As in previous years, the modified version in the prognostic mode for the 500 and 700 mb levels was verified.

(6) TYAN78 -- An updated analog program which combines the earlier versions TYFN75 and INJAH74. The program scans history tapes for cyclones similar (within a specified acceptance envelope) to the current cyclone. For the NW Pacific region, three types of 24-, 48-, and 72-hour position and intensity forecasts are provided (straight, recurve, and combined). For all other regions, types of tracks are not segregated.

c. Testing and Results

A comparison of selected techniques is included in Table 4-5 for all western North Pacific cyclones and in Table 4-6 for Indian Ocean cyclones. In Tables 4-5 and 4-6, "X-AXIS" refers to techniques listed horizontally across the top, while "Y-AXIS" refers to techniques listed vertically. The example in Table 4-5 compares COMB to CY70. In the 394 cases available for comparison, the average 24-hour vector error was 133 nm for COMB and 138 nm for CY70. The difference of 5 nm is shown in the lower right. (Differences are not always exact due to computational round off.)

STATISTICS FOR YEAR 24 HR FCSTS

	JTWC		STRA		RECR		COMB		CY70		CY50		TCMO		CLIM		XTRP		HPAC	
JTWC	492	126																		
	126	0																		
STRA	341	122	349	135																
	135	13	135	0																
RECR	403	127	348	135	417	135														
	131	5	131	-3	135	0														
COMB	403	127	349	135	416	135	417	132												
	131	4	121	-13	132	-2	132	0												
CY70	418	127	327	135	393	135	394	133	432	141										
	140	13	127	-7	139	3	138	5	141	0										
CY50	423	126	332	135	398	135	398	133	431	141	437	136								
	135	9	130	-5	136	1	136	3	136	-4	136	0								
TCMO	153	130	103	136	128	133	128	127	130	141	131	133	156	137						
	136	6	130	-5	138	5	138	11	137	-3	137	5	137	0						
CLIM	473	125	348	135	414	135	414	132	422	141	427	136	153	135	488	160				
	158	33	151	16	160	25	160	27	161	20	161	25	166	31	160	0				
XTRP	478	125	343	134	409	133	409	132	424	141	429	135	154	137	478	160	492	143		
	142	17	134	0	142	9	142	11	143	2	143	7	142	5	142	-17	143	0		
HPAC	465	125	342	134	407	133	407	132	415	140	420	135	151	135	478	160	478	142	478	130
	129	4	121	-12	131	-2	131	0	131	-8	131	-3	131	-3	130	-29	130	-11	130	0

NUMBER OF CASES

X-AXIS TECHNIQUE ERROR

Y-AXIS TECHNIQUE ERROR

ERROR DIFFERENCE Y-X

STATISTICS FOR YEAR 48 HR FCSTS

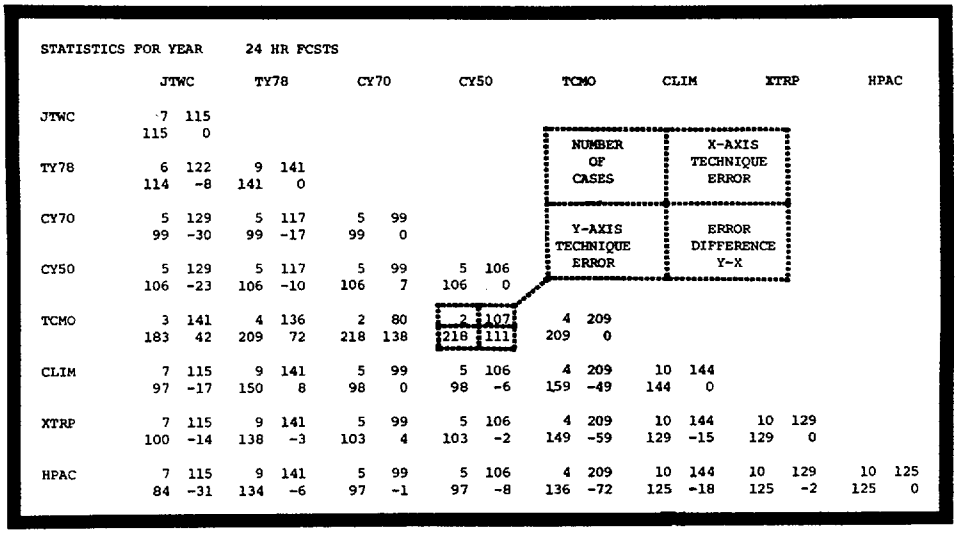
	JTWC		STRA		RECR		COMB		CY70		CY50		TCMO		CLIM		XTRP		HPAC	
JTWC	370	243																		
	243	0																		
STRA	284	243	299	295																
	288	45	295	0																
RECR	309	245	299	295	346	257														
	244	-1	251	-44	257	0														
COMB	309	245	299	295	346	257	346	243												
	232	-12	235	-59	243	-13	243	0												
CY70	311	248	277	296	322	259	322	244	350	266										
	262	15	262	-33	267	8	267	24	266	0										
CY50	318	247	283	296	328	259	328	244	350	266	357	256								
	254	7	253	-43	257	-1	257	13	254	-11	256	0								
TCMO	115	262	92	304	108	269	108	253	107	258	109	248	128	259						
	251	-10	241	-62	248	-20	248	-4	254	-3	254	6	259	0						
CLIM	356	243	296	294	341	257	341	242	338	266	345	257	124	252	394	300				
	281	38	279	-15	301	44	301	59	303	37	303	46	307	55	300	0				
XTRP	362	244	296	293	340	255	340	241	344	266	351	255	126	257	386	297	399	306		
	303	60	300	6	304	49	304	63	306	40	307	51	323	66	302	5	306	0		
HPAC	351	243	294	293	337	255	337	241	334	265	341	256	122	250	386	297	386	302	386	255
	244	1	242	-50	255	0	255	14	255	-9	256	0	269	19	255	-41	255	-47	255	0

JTWC - OFFICAL JTWC FORECAST
STRA - STRAIGHT (TYAN 78)
RECR - RECURVE (TYAN 78)
COMB - COMBINED (TYAN 78)
CY70 - CYCLOPS 700-MB PROG
CY50 - CYCLOPS 500-MB PROG
TCMO - TROPICAL CYCLONE MODEL (ONE-WAY)
CLIM - CLIMATOLOGY
XTRP - 12-HOUR EXTRAPOLATION
HPAC - MEAN OF XTRP AND CLIMATOLOGY

STATISTICS FOR YEAR 72 HR FCSTS

	JTWC		STRA		RECR		COMB		CY70		CY50		TCMO		CLIM		XTRP		HPAC	
JTWC	268	389																		
	389	0																		
STRA	212	394	242	451																
	421	27	451	0																
RECR	228	393	242	451	268	386														
	371	-21	376	-74	386	0														
COMB	228	393	242	451	268	386	268	378												
	364	-28	373	-77	378	-7	378	0												
CY70	221	403	220	455	245	394	245	380	263	419										
	416	13	416	-38	420	26	420	40	419	0										
CY50	228	399	228	454	252	392	252	379	262	419	270	419								
	422	23	412	-41	419	28	419	40	417	-1	419	0								
TCMO	66	437	60	472	68	398	68	374	66	398	68	415	83	349						
	361	-74	343	-128	326	-72	326	-47	342	-55	341	-73	349	0						
CLIM	258	394	239	446	265	387	265	375	257	418	264	422	80	341	305	445				
	429	35	425	-20	449	62	449	73	449	30	449	27	427	85	445	0				

TABLE 4-5.
ERROR STATISTICS FOR THE WESTERN NORTH PACIFIC FOR 1980



STATISTICS FOR YEAR 24 HR FCSTS

	JTWC	TY78	CY70	CY50	TCMO	CLIM	XTRP	HPAC
JTWC	7 115 115 0							
TY78	6 122 114 -8	9 141 141 0						
CY70	5 129 99 -30	5 117 99 -17	5 99 99 0					
CY50	5 129 106 -23	5 117 106 -10	5 99 106 7	5 106 106 0				
TCMO	3 141 183 42	4 136 209 72	2 80 218 138	2 107 218 111	4 209 209 0			
CLIM	7 115 97 -17	9 141 150 8	5 99 98 0	5 106 98 -6	4 209 159 -49	10 144 144 0		
XTRP	7 115 100 -14	9 141 138 -3	5 99 103 4	5 106 103 -2	4 209 149 -59	10 144 129 -15	10 129 129 0	
HPAC	7 115 84 -31	9 141 134 -6	5 99 97 -1	5 106 97 -8	4 209 136 -72	10 144 125 -18	10 129 125 -2	10 125 125 0

NUMBER OF CASES

X-AXIS TECHNIQUE ERROR

Y-AXIS TECHNIQUE ERROR

ERROR DIFFERENCE Y-X

STATISTICS FOR YEAR 48 HR FCSTS

	JTWC	TY78	CY70	CY50	TCMO	CLIM	XTRP	HPAC
JTWC	2 93 93 0							
TY78	1 90 245 156	5 285 285 0						
CY70	0 0 0 0	1 320 126 -193	1 126 126 0					
CY50	0 0 0 0	1 320 369 49	1 126 369 243	1 369 369 0				
TCMO	1 90 271 181	3 312 303 -8	1 126 306 179	1 369 306 -62	3 303 303 0			
CLIM	2 93 326 233	5 285 419 134	1 126 504 378	1 369 504 135	3 303 418 115	6 401 401 0		
XTRP	2 93 72 -20	5 285 184 -100	1 126 221 95	1 369 221 -147	3 303 200 -102	6 401 158 -241	6 158 158 0	
HPAC	2 93 144 51	5 285 278 -5	1 126 358 231	1 369 358 -10	3 303 271 -31	6 401 260 -140	6 158 260 101	6 260 260 0

JTWC - OFFICAL JTWC FORECAST
TY78 - ANALOG (TYAN 78)
CY70 - CYCLOPS 700-MB PROG
CY50 - CYCLOPS 500-MB PROG
TCMO - TROPICAL CYCLONE MODEL (ONE-WAY)
XTRP - 12-HOUR EXTRAPOLATION
HPAC - MEAN OF XTRP AND CLIMATOLOGY

STATISTICS FOR YEAR 72 HR FCSTS

	JTWC	TY78	CY70	CY50	TCMO	CLIM
JTWC	1 167 167 0					
TY78	1 167 389 222	2 427 427 0				
CY70	0 0 0 0	1 465 77 -387	1 77 77 0			
CY50	0 0 0 0	1 465 681 216	1 77 681 604	1 681 681 0		
TCMO	1 167 306 138	2 427 304 -122	1 77 303 226	1 681 303 -377	2 304 304 0	
CLIM	1 167 513 346	2 427 636 209	1 77 760 683	1 681 760 79	2 304 636 332	3 585 585 0

TABLE 4-6.
ERROR STATISTICS FOR THE NORTH INDIAN OCEAN FOR 1980